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PERFORMANCE OF *PISTIA STRATIOTES* (L.) AS AFFECTED BY WATER SOLUBLE FRACTIONS OF UNIVERSAL ENERGY AKWA IBOM CRUDE OIL IN ABRAKA, DELTA STATE, NIGERIA

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ABSTRACT
Environmental pollution and degradation caused by the processing and refining of crude oil has been on the increase since its discovery in the Niger Delta region of Nigeria. Its negative impacts are unquantifiable though its refined products are of immense benefits to the nation and the world at large. An assessment of the performance of *Pistia stratiotes* as affected by the water soluble fraction of Universal Energy Akwa Ibom crude oil was carried out in Abraka, Delta State, Nigeria in 2023. The five levels of WSF (0, 10, 25, 50, 75 and 100%) were used. *Pistia stratiotes* thalli were obtained from below the Bridge along River Ethiope and exposed to the different treatments. The results showed a significant reduction ($p \leq 0.05$) in all the plant parameters measured (leaf area, plant number, fresh weights, dry weight biomass, relative growth rate and survival percentage) in plants grown in the WSF media when compared to their counterparts exposed to the control plots. Against the normal healthy plants observed in the control, signs of dieback, yellowness of leaves, suppress growth and deaths were observed in plants subjected to the water soluble fraction of the crude oil and the effects were WSF dose dependent. There was gradual reduction in the shoot biomass of the plant with increasing level of WSF. There is a gradual increase in the root biomass although there was a total root growth. The study has established that the performance of *Pistia stratiotes* was significantly affected by the presence of water soluble fraction of crude oil. The study has great implication on water biology and food security. Continuous environmental monitoring and remediation exercises should be conducted in oil producing communities by the government.

Keywords: Performance, *Pistia stratiotes,* water soluble fraction, crude oil

INTRODUCTION
Although the oil industry has significantly improved the socio-economy of Nigeria and other oil producing countries, it is not without health and environmental risks (Agbogidi *et al.,* 2006). The environmental pollution and degradation associated with the oil industry is unquantifiable (Agbogidi *et al*., 2007a). The effect varies from one ecosystem to ecosystem, the pollutant and the quantity, time of pollution and ecological components and the complexity of the constituent hydrocarbons (Agbogidi, 2006). Crude oil has different distillates and each of them has been shown to be toxic to the environment and biota (Agbogidi *et al.,* 2006). The water soluble fraction of crude oil is the small but main fraction of the crude oil that is fully or sparingly soluble in water (Agbogidi and Bamidele, 2000). It contains a mixture of heavy metals, polycyclic aromatic hydrocarbons, volatile hydrocarbons, phenols and heterocyclic molecules (Elijah, 2022; Silva *et al.,* 2022). It is a complex mixture of hydrocarbon that aquatic organisms directly end in oil spills and it plays important role in the toxicity of crude oil to aquatic life forms. Agbogidi (2007) noted that the fate of oil in the environment is determined by factors including the evaporation of lighter volatile fractions, dissolution of the water soluble fraction, photochemical oxidation and microbial degradation process. Other factors that influence the solubility of hydrocarbons include temperature, salinity as well as the presence of other dissolved organic compounds (Agbogidi, 2006). The effects of water soluble fractions of crude oil on plants have been variously reported by different authors. Bamidele and Agbogidi (2000) noted growth reduction in *Salvinia nymphellula* and *Azolla Africana* in terms of plant number, leaf area, fresh and dry weight, relative growth rate and percentage survival with increasing level of WSF in the growth medium. Although less complex than crude oil, WSF has been reported to be a potent herbicide (Agbogidi, 2006) and hence very toxic to aquatic life forms due to biomagnification because of their non-biodegradability (Agbogidi *et al*., 2020b). *Pistia stratiotes* is a perennial free floating invasive aquatic weed (herb) with thick succulent leaves, profuse underwater stolons and long with unbranched fibrous root that could be attach to the bottom of shallow water (Bamidele and Agbogidi, 2000; Agbogidi *et al*., 2023a). The leaves spirally arranged and reproduces mainly, vegetative by buds and stolons (Agbogidi *et al*., 2022). *P. stratiotes* is a common aquatic weed that occurs in still waters, ponds or in slow flowing rivers and streams throughout West Africa. Agbogidi (2021), Horoon (2022), Agbogidi *et al*. (2022a) noted the normal roles of aquatic macrophytes in water bodies include food production, oxygenation, bio-indication, habitat diversification, erosion control and stabilization of sediments among others. The effects of WSF of crude oil on aquatics have outline to include blockage to air spaces and hence suppress leaf elongation and growth and consequently food security. *P. stratiotes* has also shown some promises in the area of accumulation of pollutants and heavy metals. Although some works have been conducted on other aquatic plants including *Azolla africans, S. nymphellula, Racemos repens* and others there is scarcity of documented information on the *Pistia stratiotes*, a common aquatic weed of fresh waters (Mostafa *et al*., 2021, Bamidele and Eshagberi, 2015, Ogbo *et al.,* 2009). Besides, most oil spills take place in aquatic ecosystem. It is against this background that this study has been embarked upon to provide information on the performance of *P. stratiotes* as affected by the WSF of Universal Energy Akwa Ibom crude oil with a view to document and recommend the outcome as a potential aquatic plant for remediation in case of water pollution as future prospective. The study also aims at providing information on the physicochemical parameters and heavy metal index of crude oil. It

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is believed that findings from this research will be of help to decision makers, environmental enthusiastic and water users.

MATERIALS AND METHODS

The study was carried out at the Screen House of the Department of Botany, Delta State University, Abraka. Abraka lies between latitude 05°47'N and longitude 06°06'E of the equator with an annual rainfall of 3,097mm, annual relative humidity of 83% and annual mean temperature of 30.60°C (Efe and Aruegodor, 2003).

Sample collection

The plant, *P. stratiotes* was collected from River Ethiope behind the bridge, Abraka. The plants were gathered and carried in plastic bags to the laboratory and transferred to the aquarium for seven days to culture and to acclimatize them before further use after washing with tap water to remove dirt and debris that could have accompanied them. The crude oil was collected from NNPC, Warri, Delta State.

Preparation of water soluble fraction of crude oil

Distilled water was used to prepare the water soluble fraction of the crude oil.

After 24 hours of shaking, the water soluble fraction was siphoned into a dark coloured screw capped Winchester bottles referred to as the 100%/stock. The stock was diluted to give 75, 50, 25 and 12.5% strength WSF and also stored in screw capped bottles. The pH of the WSF was adjusted to 6.5. 500 cm^3 of each of the distilled WSF and the stock as well as the nutrient medium which served as the control. The set up was monitored for six (6) weeks. The set up was a completely random block design and replicated three times.

Determination of growth parameters

The parameters determined were leaf area, plant (thallus) number, fresh weight, dry weight, shoot/root (S/R) ratio, percentage survival and relative growth rate.

Leaf area determination

Plant height was measured with the aid of a measuring tape, numbers of leaves were physically counted and leaf area measured following Agbogidi and Ofuoko (2005).

Plant (thallus) number determination.

It was determined by counting the number of thalli produced per week following the procedure of Bamidele and Agbogidi (2000).

Determination of fresh weights, dry weights and shoot/root ratio

The fresh weights and dry weights were determined after six weeks of treatment following the procedure of AOAC (2010). The plants were cleaned with white clots tissue paper to remove water and dusts before weighing. The plants were separated into leaves (shoot) and roots and weighed. They were separately oven dried based on levels of treatments and weighed again for dry weight using the Methlan E200 electric weighing balance.

Determination of shoot/root ratio

This was done by dividing the shoot dry weight values by the root weight values.

Determination of relative growth rate (PGR)

This was calculated following the procedure of Hoffmann and Poorter (2002)

$$PGR = \frac{\log W_1 - \log W_2}{T_1 - T_2}$$

Where: W_1 = Final weight
W_2 = Initial weight
T_1 = Final time
T_2 = Initial time

Determination of physicochemical parameters

The physicochemical parameters of the WSF were determined using standard procedures (APHA, 2012).

Statistical analysis

The data collected were subjected to one way analysis of variance and treatment means were separated by Duncan's Multiple Range Tests using SAS (2010) at $p \leq 0.05$.

Determination of heavy/trace metals

The trace metal contents of the WSF were determined using the Atomic Absorption Spectrophotometer (AAS, Unicam 969) and the level of the metals was read following the procedure of AOAC (2010).

RESULTS AND DISCUSSION

The results on the growth characteristics of *Pistia stratiotes* as affected by water soluble fraction of the crude oil are presented in Tables 1 to 5 (leaf area, plant/thallus number, fresh weight, dry weight, shoot/root ratio and relatively growth rate) respectively.

Table 1 shows the performance of *P. stratiotes* (leaf area) as affected by the water soluble fraction of Universal Energy Akwa Ibom crude oil. The table shows that *P. stratiotes* plants grown in control plots showed significant highest values which were significantly different $p \leq 0.05$ when compared with their counterparts grown in the contaminated plots. While the mean value for the unpolluted plot was 152.17 cm^3, the value for *P. stratiotes* plants subjected to 75% WSF and 100% were 52.87 cm^2 and 19.25 cm^2 respectively. The results also indicated that growth reductions were concentration of WSF dependent (Table 1). In the same vein, the plant number of *P. stratiotes* subjected to the control plots had appreciable number and this value was significantly higher than the number observed in the plots with different contamination levels. The trend is also similar to what was observed in the plant height.

Table 1: Performance of *Pistia stratiotes* as affected by water soluble fraction of Universal Energy Akwa Ibom crude oil.

Concentration of WSF (%)	Leaf area/Weeks after planting (cm^2)						
	1	2	3	4	5	6	Means
0	96.70	128.63	140.70	164.61	181.77	200.60	152.17[a]
25	92.62	100.64	103.78	105.72	107.30	115.71	104.46[b]
50	84.71	90.36	93.41	94.39	98.76	99.34	93.49[c]
75	50.73	53.40	53.56	53.46	53.00	53.00	52.87[d]
100	46.10	35.62	33.80	0.00	0.00	0.00	19.25[e]

*Means with same letters are not significantly different using the Duncan's Multiple Range Tests.

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Table 2: Plant (thallus) number of *Pistia stratiotes* as affected by the crude oil

Concentration of WSF (%)	Plant number/Weeks after planting (cm^2) 1	2	3	4	5	6	Means
0	2	4	4	6	8	10	5.5^a
25	2	2	3	5	6	7	4.2^b
50	2	2	2	3	4	5	3.0^c
75	1	1	2	2	3	4	2.2^d
100	1	1	1	1	1	1	1.0^e

*Means with same letters are not significantly different using the Duncan's Multiple Range Tests.

Significant reductions (p≤0.05) were recorded for all the fresh weight of the shoot with increasing level of WSF. While the highest value (4.00 g and 0.20 g) were observed for the leaves fresh weight and root weight of the control plots, significant decrease was obtained for the shoot fresh and dry weights in plants grown in the treated media. The decrease also showed WSF concentration dependent. The root weights, both fresh and dry showed a gradual increase and they were significantly different from values obtained in the control (Tables 3 and 4). The shoot/root ratio followed the same trend as that observed for the fresh and dry weights.

Table 3: Weight (fresh) (g) of *Pistia stratiotes* as influenced by WSF crude oil

Concentration of WSF (%)	Leaves	Roots weights (g)	Shoot/Root
0	4.00^a	0.20^d	20.00^a
25	3.31^b	0.44^c	7.52^b
50	2.40^c	0.48^b	5.00^c
75	2.00^d	0.49^a	4.08^d
100	1.42^d	0.50^a	2.84^e

*Means with same letters are not significantly different using the Duncan's Multiple Range Tests.

Table 4. Weight (dry) (g) of *Pistia stratiotes* as affected by WSF crude oil

Concentration of WSF (%)	Dry weights (g) Leaves	Roots	Shoot/Root
0	0.38^a	0.01^d	38.00^a
25	0.36^b	0.02^c	18.00^b
50	0.25^c	0.02^c	12.50^c
75	0.20^d	0.03^b	6.67^d
100	0.10^e	0.04^a	2.50^e

*Means with same letters are not significantly different using the Duncan's Multiple Range Tests.

The observed reduced growth in *P. stratiotes* plants subjected to highest level of the water soluble fraction could be attributed to the presence of toxic hydrocarbon properties which Bamidele and Agbogidi (2000) reported to be the most toxic substances present in crude oil. *Pistia* plants could have absorbed the toxic substances into their cells and tissues and hence the reduced growth and eventual death at high level of treatment. The death of the plants could also be attributed to the imbalance created within the plant tissues. This observation is in line with prior reports of Agbogidi *et al.* (2006); Agbogidi *et al.* (2007a) and Agbogidi and Eshegbeyi (2006) on *Zea mays* and *Dacroyodis edulis* which shows that crude oil or its distillates are potent contact herbicides. On entering the plant, they could have endangered the life of the plant through disturbed metabolism including growth activities of the plant hence the reduced growth parameters and gradual death. Similar observation had been reported by Agbogidi *et al.* (2006) on *Racemose repens,* a wetland species.

The reduced growth parameters including leaf area, plant number, fresh weights, dry weight and shoot/root ratio observed in *Pistia* plants grown in lower level of the water soluble fraction could indicate that crude oil contain some growth promoting substances that could have been made available to the plant at low concentration. This observation is in harmony with earlier reports of Agbogidi *et al*. (2007) and Agbogidi *et al*. (2007a) who observed enhanced growth in maize in the presence of crude oil at low concentrations. The observed decrease in the plant number of *P. stratiotes* grown in higher concentration could be seen as a reduced multiplication rate caused by accumulation of and products brought about by suppression of translocation in the source (leaf). Other possibilities could include disruption of photosynthesis apparatus in the plant, prolongation of cell enlargement, disruption or damage to cell wall as well as alteration of the pH of the growth medium by the WSF of the oil beside the characteristics of the crude oil. These observations agree with earlier reports of Agbogidi *et al.* (2007b). The reduced relative growth rate observed in *P. stratiotes* grown in contaminated media indicated that crude oil and its components have a negative effect on the growth of the test plant. This could have affected the flow of nutrients and hence the reduced growth. A decrease in the biomass caused an increase in the WSF is in agreement with earlier reports of Agbogidi (2006) for *Racemose repens*. The observed increase in the root weight with increasing concentration of the WSF showed that root growth was favoured at higher levels. Root stimulation following WSF application as observed did not necessarily increase the total growth but it could just be an adaptation to stress condition by the plant. This finding corroborates earlier reports of Bamidele and Agbogidi (2000) and Agbogidi (2006) that due to suction tension of the environment, the plant used more dry weight to form roots. The study also recorded the presence of some heavy metals in the WSF impacted media when compared with the uncontaminated media. The presence of the physicochemical properties and trace metals Pb, Zn, Co, Cr, Cd and Fe in the WSF could have also immobilized nutrients where they could be present but not in available forms. The presence of heavy metals in crude oil and its distillates had been reported by Agbogidi and Erhenhi (2013).

Conclusion

The study assessed the performance of *Pistia stratiotes* as influenced by the water soluble fraction of Universal Energy Akwa Ibom crude oil. The study reported that the performance of *P. stratiotes* in terms of leaf area, plant number, fresh and dry weights, relative growth rate and percentage survival is significantly affected by the WSF of the crude oil. This study has great implications on water biology and aquatic food security.

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